

warnings of the 6th and the 24th doubtless resulted in the saving of much property and many lives.—*J. W. Smith, District Forecaster.*

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

The rainfall was excessive and the temperature deficient. A severe cold wave, the first of the season, past over the district from the 10th to the 14th, when freezing temperatures occurred almost to the coast line. Timely warnings for frost and freezing temperatures were issued for the northern portion of the district on the 9th and for other portions on the 10th, 11th, 12th, and 13th. The warnings, which were widely distributed, enabled the protection of vegetation and the windrowing of sugar cane in exposed localities. Cold waves occurred in some sections without warnings, but the warnings for freezing temperature served all public interests in these localities. Frost warnings, which were partially verified, were issued for limited areas on four other dates. No general frost or freeze occurred without warnings. Storm warnings were issued on the 11th, 16th, and 19th, and brisk to high winds occurred during the display in each instance. No general storm occurred without warnings.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

During the month seasonable conditions largely prevailed for the district as a whole. In Kentucky the temperature and precipitation were both somewhat below normal, but in Tennessee these elements averaged nearly normal, except in the northeastern portion, where the rainfall was nearly double the average November amount. Clear skies largely predominated, being in decided contrast to last year.

There were six marked disturbances during the month. Two of these, the 1st-2d and the 30th, moved in from the northwest, while the other four—17-18th, 19-20th, 22d-24th, and 28th—were from the southwest, or west Gulf section. The storm of the 19-20th, which moved from Texas up the Mississippi Valley to the Lakes, was the most severe, being attended by heavy rains and high winds.

There were no cold waves, and no special warnings were issued, altho advice of decidedly colder weather was sent out the morning of the 10th.—*F. J. Walz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The month was characterized by a marked deficiency in precipitation and an unusual amount of sunshine over the entire district; the temperature was above the normal, except in the extreme eastern portions.

No cold waves occurred during the month, and there was no considerable fall of snow, except on the 30th, when a fall of several inches occurred in the western Lake region. Special snow warnings were issued for southern lower Michigan and northern Illinois.

The month was unusually free from severe windstorms on the Great Lakes. Warnings were issued on eight dates in advance of storms of moderate energy, and no casualties were reported.—*H. J. Cox, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

The month was cool and generally dry. There were comparatively few marked changes in temperature. Rain or snow fell on but few days, and was generally below the normal amount.

No special warnings were issued. Moderate cold waves, without warnings, occurred as follows: Northeastern Colorado, on the 10th; central Wyoming, on the 19th; and northwestern Wyoming, on the 27th. These cold waves were not marked by unusually low temperatures.—*P. McDonough, Local Forecaster, temporarily in charge.*

SAN FRANCISCO FORECAST DISTRICT.†
[California and Nevada.]

This was the driest November recorded at this station during a period of fifty-nine years, excepting only November, 1890, which was without any rain over a large portion of the State. At San Francisco there were but three rainy days, the total amount being .04 inch. The normal amount at San Francisco in November, based upon a fifty-nine years record, is 2.64 inches, so that the deficiency during the current month is very marked. The chief cause was the presence of a persistent high area over the Rocky Mountain section, the basin ranges, and the Pacific slope. This has caused northerly winds thruout California and a large portion of Nevada, with cool mornings and high afternoon temperatures.

A number of frost warnings were issued during the month, but there were no injurious frosts, and no special warnings were necessary.—*A. G. McAdie, Professor and District Forecaster.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The month was uniformly mild, and the rainfall was somewhat less than normal. The center of a severe disturbance past over the northern boundary of the district on the 1st. This was followed by a long period without storms that lasted until the 19th, when disturbances again began crossing the North Pacific States, and continued with great frequency nearly up to the close of the month. Eight warnings for storms were issued, and with hardly an exception they were fully verified. The most severe storm occurred on the 25th, at which time maximum velocities of slightly over 70 miles an hour occurred at the coast stations, and the unusually high velocity of 51 miles was reported at Seattle, Wash. Notwithstanding the long period of stormy weather no noteworthy marine casualties occurred, and this of itself bespeaks the value of the warnings.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

The stages of the rivers of the Mississippi system did not depart greatly from their usual averages for the time of the year. There was a fair rise in the Ohio River about the middle of the month. It past into the Mississippi on the 20th and reached the Gulf of Mexico about December 3.

The rains of the 6th and 7th caused a general rise in the rivers of southern New England and the Middle States, but not to within several feet of the flood stages, except in the lower Connecticut and Hudson rivers. Both of these rivers had been quite high as a result of frequent rains over the upper watersheds, so that the heavy rains of the 6th and 7th were certain to result in some high water. Warnings for the lower Connecticut were issued on the 7th, and on the morning of the 8th the stage of the river at Hartford was 19.7 feet, 3.7 feet above the flood stage. The crest stage of 20.3 feet was reached on the morning of the 9th, after which the decline set in. The damage and losses were trifling, as the water had not had an opportunity to recede greatly from the high stage of October 31.

Warnings were issued on the 7th for flood stages in the Hudson River in the vicinity of Albany. The flood stage of 12 feet at Albany was past during the night of the 7th, and by the morning of the 9th the water stood at 13.9 feet, 1.9 feet above the flood stage, and practically the exact stage that had been forecast. At Troy, N. Y., the crest stage was 18 feet, 4 feet above the flood stage.

Advisory warnings were issued on the 22d and 23d for a moderate rise in the Alabama River, and on the 23d for a similar condition in the Oconee and Ocmulgee rivers of Georgia. Warnings were also issued at the proper time for the flood that occurred in the Wateree River of South Carolina on the 24th and 25th, and for the flood stage in the lower Roanoke River on the 26th.

The heavy rains that fell over eastern Texas from the 15th to the 20th, inclusive, were followed by moderate floods in the rivers of that district, except in the Neches, and the upper portions of the Brazos and Colorado rivers. Flood stages were exceeded, but not to any decided extent, except in the valley of the Guadalupe and lower Colorado rivers, where the rains had been heavier, resulting in stages from 7 to 10 feet above the flood stages. Warnings were issued regularly from the 18th until the 20th, inclusive, and no reports of damage or loss have been received. The rivers of the Pacific States were quiet.

The highest and lowest water, mean stage, and monthly

range at 197 river stations are given in Table VI. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

PHENOMENA CONNECTED WITH THE SAN FRANCISCO EARTHQUAKE.

By Dr. C. M. RICHTER and Prof. ALEXANDER G. McADIE. Dated San Francisco, Cal., December 28, 1907.

A number of phenomena have been reported in different publications (*Science*, *Nature*, *Gaea*, and others), as observed during and after the earthquake of April 18, 1906, which it seems to us need more accurate description and a statement of the facts as we know them, who were present at the time and made notes of them.

First, we may call attention to earthquake sounds. Such sounds were reported by many people after the earthquake. Many claim to have heard a sound comparable to an approaching windstorm or the roll of a heavy wagon; but in our judgment most of these sounds can be explained by the noise due to violent shaking of dwellings. There are, however, some reports of a sound like that of a violent wind preceding the first shake. We have no record of any detonation coming from the ground.

With regard to light and fire phenomena a number of statements have been made, many of which have been shown to be erroneous by "D. S. J." in *Science*.¹ Some of the most elaborate and detailed statements of such phenomena were given by those who were not in San Francisco during the earthquake.

We have no proof whatever that any particular optical or electrical phenomenon occurred preceding, during, or following the earthquake. The atmospheric conditions preceding and at the time of the earthquake are described in the report of the California section of the Climatological Service of the Weather Bureau for April, 1906. This report states:

The morning of Wednesday, April 18, was clear and pleasant over the greater portion of the Pacific coast. An area of high pressure was moving steadily and somewhat slowly eastward over Idaho. The weather map gives the conditions existing a few minutes previous to the great earthquake, and it may be noted that the pressure distribution is of a type that has been found to prevail when certain earthquakes occur in California. A study of the relation of atmospheric pressure and earth movement had been under way in the office of the Weather Bureau at San Francisco for some years, and while no very definite conclusions had been arrived at it was plain that the greater number of earthquakes in California occurred apparently without any relation to pressure distribution. It was noticed, however, that some earthquakes occurred during the passage of a marked high across the northern portion of the coast. While any relation of this character must be obscure and indefinite, it is conceivable that in a region where quakes and tremors of tectonic origin are frequent—i. e., a region where strata are in unstable equilibrium—the passage of an area of high pressure may directly or indirectly affect the stresses at critical times. The relation is involved and is alluded to here only because at Manila and Tokyo microseismic phenomena bear some relation to approaching typhoons. The thought suggests itself that the installation of seismographs on the Pacific coast may lead to the detection of advancing pressure areas.

A. Sieberg² asserts that "die Erdbeben die örtliche witterung nicht beeinflussen", and later³ "Die Luftdruckschwankungen vermögen den Eintritt von Dislokationsbeben zu fördern". His material would rather favor a falling bar-

ometer as a causative factor. At the time of the San Francisco earthquake there was a well-defined high over practically the entire area of the United States. Similar barometric conditions had occurred at the beginning of April and at other times. The high of April 18 had no unusual characteristics.

Much has been said by various reporters about the high winds and marked indrafts of air due to the fire. It has been said that the strong winds caused by the fire were felt miles at sea. Concerning this, the best comment that can be made is that the instruments of the Weather Bureau were in place thruout the entire day of April 18. The Weather Bureau records are continuous up to 5 p. m. of the 18th, or, in other words, for a period extending thru the earthquake and twelve hours after the earthquake. These records are available, and show that there were no unusual features connected with air motion. The wind had been westerly on April 17, with a velocity of 14 miles an hour, the sky clear and the weather pleasant. A few minutes preceding the earthquake the wind was from the west, velocity 3 miles per hour, weather clear. At 5 p. m. of the 18th the pressure, reduced to sea level, was 30.15 inches; the temperature of the dry-bulb thermometer, 61.8° F., of the wet-bulb thermometer, 54.0°; and the direction of the wind, west, the velocity, 22 miles an hour. In brief, then, there was nothing remarkable in a meteorological way during the twenty-four hours under consideration. It was a pleasant spring day.

Some reports have been published concerning unusual clouds formed early during the fire and described as caused by the fire. One of the writers of this article photographed the smoke cloud as early as 8 a. m., that is to say, less than three hours after the beginning of the fire. These clouds were also carefully observed by observers of the Weather Bureau. They were, so far as we could determine, purely smoke masses, and the general elevation of the top of these clouds was probably not above 500 feet. Certain peculiarities have been reported concerning these clouds.⁴ Except for their size and density, we who closely observed these appearances at the beginning and during the whole period of the fire remember seeing nothing that can not be explained as smoke effects, such as a large fire would cause. While the appearance of the smoke at different hours was interesting, there was no unusual or phenomenal cloud development. So far as we could determine, there was no marked indraft of air caused by the intense heat. The lower air movement agreed with the usual movement due to the passage of an area of high pressure, the light north and northeast winds giving way to moderately strong west winds. It was apparently this change that prevented the complete destruction of San Francisco by fire.

There was no tidal wave or unusual disturbance in the Bay of San Francisco. As a matter of fact, the waters of San Francisco Bay were unusually calm on April 18, before, during and after the earthquake. In this connection it might not be

¹ Issue of August 10, 1906.

² *Handbuch der Erdbebenkunde*, 1904, p. 124.

³ *Ibid.*, p. 126.

⁴ See *Science*, November 14, 1906; *Nature*, vol. 74, 1906, p. 133; also *Science*, April 5, 1907, p. 554.